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<th><strong>Title</strong></th>
<th>Air stable Cs2Snl6 sensitizers : synthesis, investigation of crystal structure and its optoelectronic properties</th>
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<td><strong>Author(s)</strong></td>
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**Introduction**

Despite reports of high efficiencies for organolead trihalide (CH$_3$NH$_3$PbI$_3$) based solar cells, its commercialization remains hampered by the presence of soluble lead compounds. Attempts to replace atoms in the typical ABX$_3$ structure, such as in CH$_3$NH$_3$SnI$_3$ and CsSnI$_3$, have resulted in perovskites with long term instability issues associated with phase transitions and ambient hydrolysis, driving the research to uncover lead-free, air-stable substitutes.

A type of molecular iodosalt, Cs$_2$SnI$_6$ exhibits air and moisture stability attributed to Sn +4 oxidation state, unlike the +2 in CH$_3$NH$_3$SnI$_3$ and CsSnI$_3$. These, coupled with its solubility in common laboratory solvents, makes it ideal for ambient processing. Recent report on hole transporting capability of the cubic structured Cs$_2$SnI$_6$ in solid state dye sensitized solar cell (DSSC) has motivated the synthesis and characterization of high purity Cs$_2$SnI$_6$ to assess its suitability as a light absorber.

**Characterization**

Homogeneity of film plays a crucial role in material characterization and device performance. This necessitates solvent engineering to obtain a well dispersed layer to ensure accuracy, reliability and reproducibility of data.

**Material Synthesis**

Two synthesis techniques were employed in an attempt to obtain high purity Cs$_2$SnI$_6$, namely precipitation and melt (Fig. 2).

**Precipitation**

$$
2CsI(aq) + SnI_4(aq) \rightarrow Cs_2SnI_6(s)
$$

**Melt**

$$
2CsI(s) + SnI_4(s) \rightarrow Cs_2SnI_6(s)
$$

As shown above (Fig. 3), pure Cs$_2$SnI$_6$ was successfully synthesized using the precipitation method. XRD patterns from Cs$_2$SnI$_6$ thin films with DMF as solvent (Fig. 4) showed linear relationship between CsI content and annealing temperature, implying a need for solvent engineering and temperature optimization.

**Device Fabrication and Testing**

Solutions of Cs$_2$SnI$_6$ in DMF and DMF + HI resulted in films with poor surface coverage with large crystal formation (1-6 um) (Fig. 5). Presence of CsI in XRD patterns of these films also indicate possible degradation due to solute-solvent interaction (Fig. 6). High purity film with smaller crystal sizes (~700nm) and better coverage were attained with deionized water as solvent (Fig. 5 & 6). Increased crystallinity, correlated with improved device performance, was seen at elevated annealing temperature (Fig. 7).

**Conclusion**

Low efficiencies observed is likely due to insufficient loading of perovskite in the mesoporous layer, as evidenced by incomplete penetration of the absorber in the screen printed cell leading to low currents. Infiltration of the perovskite for screen printed films can be improved through addition of valeric acid. Further optimization of blocking and absorber layers necessary to improve fill factor and current density respectively.

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**Project Title: Perovskite Solar Cells**

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